Influence of Irrigation Method, Tillage, and Crop Residues on Infiltration and Interrill Erosion on a Pullman Soil

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Summary

Runoff and erosion were measured from graded furrow and sprinkler irrigated plots representative of typical agricultural production practices in the Southern High Plains. Initial infiltrometer measurements have shown that residue management with no-till or ridge-till systems enhanced infiltration capacity for the wheat residue phase of a wheat-sorghum-fallow rotation. Sprinkler irrigated plots had greater infiltration rates than the graded furrow irrigated plots. These preliminary results show that conservation tillage with irrigated production can reduce erosion potential on the Pullman soil.

Project Description

The Southern High Plains has significant environmental degradation from both water and wind erosion. In particular, irrigated lands are often unprotected without residues or crops during periods with high rainfall probabilities. Rain events in the Southern High Plains can have high intensities resulting in highly erosive conditions. This region is shifting from graded furrow irrigation to center pivot sprinkler irrigation, which has a wide range of application methods from impact sprinklers to LEPA (low energy precision application). Closely spaced spray devices used on many pivots have small wetted diameters and high instantaneous application rates that can create runoff and erosion problems.

Project objectives are to evaluate the effects of cropping systems on runoff, infiltration, and erosion from irrigated cropland in the Southern High Plains of the United States and to evaluate, verify, and validate the USDA-ARS WEPP (Water Erosion Prediction Project) model of erosion from rainfall- and irrigation-induced runoff. In particular, soil surface physical and chemical effects are being measured as crop residues are either left standing following harvest (no-till with chemical fallow) or incorporated with conventional tillage for a wheat-sorghum-fallow (WSF) rotation (10 mo. wheat, 9 mo. wheat fallow, 6 mo. sorghum, 11 mo. sorghum fallow).

The two plot areas are on different parts of the USDA Conservation and Production Research Laboratory at Bushland but have similar cropping histories and have uniform Pullman clay loam soils. A 500-foot, 3-span lateral-move sprinkler system equipped with low pressure (10 psi) spray heads positioned about 5 feet above the ground and 5 feet apart is used to irrigate the sprinkler plots. The four sprinkler cropping system treatments are conventional tillage (both flat and on raised beds), no-till (flat without beds), and ridge-till (on permanent beds). The graded furrow plots are 1,320 feet long, use gated pipe with water supplied from an underground pipeline, and use similar farming equipment and management to the sprinkler plots. Conventional tillage plots were disk and sweep plowed after wheat harvest for weed and volunteer wheat control; the no-till plots used chemical weed control; and the ridge-till plots used chemical weed control with controlled, light surface tillage.

Infiltration and interrill erosion are measured with a rotating disk type rainfall simulator. The infiltrometer uses a 16 ft^2 frame that is 4 feet long on a side. Normally, rainfall intensity of 2 in/hr is used. The water source is rainwater captured with a cistern.

The plots were established in the fall of 1993 with the winter wheat crop of the WSF sequence. The third phase of the WSF rotation (sorghum fallow) was in place following the 1994 sorghum harvest. The 1995 season will be the first complete season with all phases in place. Infiltration measurements will be conducted mainly in 1995 on the wheat residues from the 1993-94 crop and on the sorghum residues from the 1994 crop. Preliminary results presented here were taken only on the wheat residue component of the WSF rotation in the late summer of 1994 following tillage after harvest. Conventional tillage plots were disk and sweep plowed, while the no-till and ridge-till plots had only chemical weed control after harvest.

Results

Examples of the infiltration data are shown in Fig. 1. Wheat residues after tillage averaged 2.33 and 0.45 t/ac for the no-till and conventional till plots in the sprinkler field, respectively, and 1.45 and 0.45 t/ac for the no-till and conventional till plots in the graded furrow field, respectively. The wheat residues and undisturbed soil with no-till and ridge-till maintained intake rates exceeding 1.0 in/hr even after 3 inches of simulated rain at an intensity of 2.0 in/hr, while the conventionally tilled plots with much less residue cover had infiltration rates less than 0.7 in/hr. Similar trends were observed for the furrow irrigated plots although the differences in final infiltration rates were not quite as dramatic. The flow-weighted sediment concentration for the first 1.5 inches of runoff averaged 0.22 and 0.08 t/ac per inch of runoff for the conventional tillage and no-till (same as ridge-till at this time) sprinkler plots, respecticely, as compared with 0.23 and 0.15 t/ac per inch of runoff for the graded furrow plots, respectively.
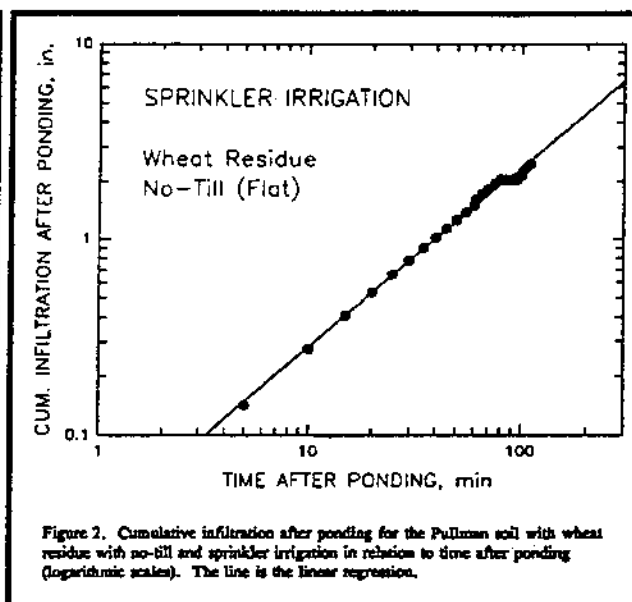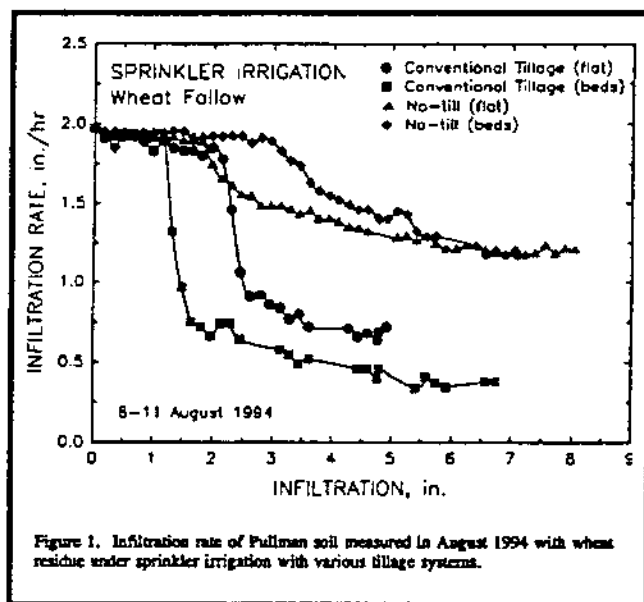
These results and data will be use to validate and test the WEPP model for erosion prediction for the Pullman soil. Initially the infiltrometer data were analyzed with the modified Kostiakov equation given as:

$$Z = Kt^a + Ct$$

where "Z" is cumulative infiltration (in), "t" is infiltration opportunity time (min), "K" is an empirical factor influenced by the surface conditions of the soil, "a" is an empirical parameter influenced mainly by the soil texture and physical factors, and "C" (in/min) describes the basic (final) infiltration rate indicative of the saturated conductivity where gravity forces dominate.

Eight sets of infiltrometer measurements were analyzed by visually determining the time to ponding (Tp in min) when infiltration declined from the application rate. "C" was determined to minimize absolute deviation between the measured and predicted cumulative infiltration. Then "K" and "a" were determined by regression using a logarithmic transformation [Log(Z - Ct) versus Log(t - T_p)]. From these preliminary measurements, the infiltration parameters are given in Table 1. Figure 2 illustrates the logarithmic relationship for equation 1 for an example set of data. The infiltration analysis demonstrates 1) that the "K" parameter is generally larger for furrow irrigated plots possibly owing to crusting; 2) the "a" parameter basically demonstrates the random variations to be expected in soil properties; 3) the Kt^a term of equation 1 characterizes early infiltration and shows 20% greater infiltration for furrow irrigation compared with sprinkler and 30% greater infiltration for no-till (or ridge-till) compared with conventional tillage; and 4) the "C" parameter shows a much greater (>220%) long-term infiltration capacity under sprinkler irrigation and greater (>120%) infiltration capacity for no-till (or ridge-till) compared to conventional tillage.

These preliminary results need further analysis and additional verification. However, they indicate the water-conserving potential of no-till and ridge-till methods to utilize crop residues to enhance infiltration properties for the Pullman soil. Although not a part of this study, the increased filtration of the reduced tillage systems may allow the transmission of chemicals into the vadose zone.

Figure 1. Infiltration rate of Pullman soil measured in August 1994 with wheat residue under sprinkler irrigation with various tillage systems.

Figure 2. Cumulative infiltration after ponding for the Pullman soil with wheat residue with no-till and sprinkler irrigation in relation to time after ponding (logarithmic scales). The line is the linear regression.

Technology Transfer

This research was featured on the tour at the 1994 Bushland Wheat Field Day in May. Dr. Arland Schneider demonstrated the plot layouts and runoff measuring and water quality equipment. A follow-up article was written by the agricultural editor of the Amarillo Globe News for the local newspaper.

Table 1. Infiltration parameters for the modified Kostiakov equation for a Pullman soil in August 1994 for wheat residues in a WSF rotation.				
Graded Furrow Irrigation				
	Conventional Tillage		Ridge Tillage	
Parameter	Plot 1	Plot 4	Plot 2	Plot 3
K	0.0190	0.1106	0.0594	0.0475
a	0.912	0.319	0.560	0.693
C(in./min)	0.0033	0.0020	0.0020	0.0052
r^2	0.991	0.987	0.990	0.985
T_p (min)	50	50	15	50
Sprinkler Irrigation				
	Conventional Tillage		Conservation Tillage	
Parameter	Beds	Flat	Beds (Ridge-Till)	Flat (No-Till)
K	0.0355	0.0325	0.0258	0.0145
a	0.657	0.610	0.799	0.812
C(in./min)	0.0033	0.0079	0.0145	0.0145
r^2	0.994	0.997	0.994	0.994
T_p (min)	35	75	90	55

Public Affairs Activities

This research will be part of the 1995 Bushland Corn Field Day to be held in early August.

Acknowledgments

Clean Water –
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Conference Proceedings

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